AFHRL-TR-76-84

# AIR FORCE

# HUMAN RESOURCES

ADA039267

## FULL MISSION SIMULATION IN UNDERGRADUATE PILOT TRAINING:
### AN EXPLORATORY STUDY

12

By

Robert R. Woodruff
James F. Smith
John R. Fuller, Capt, USAF
Douglas C. Weyer, Capt, USAF

FLYING TRAINING DIVISION
Williams Air Force Base, Arizona 85224

December 1976
Final Report for Period April 1975 – January 1976



Approved for public release; distribution unlimited.

# LABORATORY



AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

## NOTICE



This final report was submitted by Flying Training Division, Air Force Human Resources Laboratory, Williams Air Force Base, Arizona 85224, under project 1123, with HQ Air Force Human Resources Laboratory (AFSC), Brooks Air Force Base, Texas 78235.



This technical report has been reviewed and is approved.

J D. BOREN, Colonel, USAF
Flying Training Division

Approved for publication.

DAN D. FULGHAM, Colonel, USAF
Commander

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

# REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

**1. REPORT NUMBER**
AFHRL-TR-76-84

**2. GOVT ACCESSION NO.**

**3. RECIPIENT'S CATALOG NUMBER**

**4. TITLE (and Subtitle)**
FULL MISSION SIMULATION IN UNDERGRADUATE PILOT TRAINING: AN EXPLORATORY STUDY

**5. TYPE OF REPORT & PERIOD COVERED**
Final rept.
Apri[redacted]975 – Ja[redacted]76

**6. PERFORMING ORG. REPORT NUMBER**

**7. AUTHOR(s)**
Robert R. Woodruff, John R. Fuller, James F. Smith, Douglas C. Weyer

**8. CONTRACT OR GRANT NUMBER(s)**

**9. PERFORMING ORGANIZATION NAME AND ADDRESS**
Flying Training Division
Air Force Human Resources Laboratory
Williams Air Force Base, Arizona 85224

17 p.

**10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS**
62703F
11230321
03

**11. CONTROLLING OFFICE NAME AND ADDRESS**
HQ Air Force Human Resources Laboratory (AFSC)
Brooks Air Force Base, Texas 78235

**12. REPORT DATE**
Dec[redacted]76

**13. NUMBER OF PAGES**
18

**14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)**

**15. SECURITY CLASS. (of this report)**
Unclassified

**15a. DECLASSIFICATION/DOWNGRADING SCHEDULE**

**16. DISTRIBUTION STATEMENT (of this Report)**

Approved for public release; distribution unlimited.

**17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)**

**18. SUPPLEMENTARY NOTES**

AFHRL-TR-76-90 provides a comprehensive report of development of the syllabus used in this study and a copy thereof.

**19. KEY WORDS (Continue on reverse side if necessary and identify by block number)**

flying training
pilot training
simulation
simulator motion systems
simulator visual systems
training methods

**20. ABSTRACT (Continue on reverse side if necessary and identify by block number)**

Eight undergraduate pilot training students were trained to specified levels of performance in all major areas of basic pilot training using the Advanced Simulator for Undergraduate Pilot Training (ASUPT); half were trained using the platform motion system and half without. Subsequently, they completed basic pilot training (to Air Training Command (ATC) phase standards) in T-37 aircraft. Training hours required and check ride scores were compiled for each subject. Similar data were collected for a control group of eight subjects trained using the conventional ATC syllabus. Using data obtained from both groups, estimates of transfer of training percentages, and training effectiveness ratios were computed.

→ next page

(Over)

Item 20 (Continued):

cont

Simulator trained students required fewer aircraft hours in all areas of basic UPT and achieved check ride scores equal to or better than the control group. No significant or practical differences were documented between performances of the motion and no-motion trained groups for any category of maneuvers.

This was a first effort to incorporate a full mission simulator into an operational pilot training program. Several problem areas were identified which must be solved before full success can be achieved. These same problems should be relevant to application of other full mission simulators in other training programs. In addition, some ASUPT deficiencies were identified.

## SUMMARY

### Problem

The primary objective of this exploratory study was to investigate the utility of the Advanced Simulator for Undergraduate Pilot Training (ASUPT) as a full mission simulator in the basic phase of Air Force undergraduate pilot training (UPT). Secondary objectives included identification of problem areas in using a full mission simulator, equipment problems, and the effectiveness of simulator platform motion in UPT.

### Approach

A sample of eight UPT subjects were given simulator training to a satisfactory level in all flight skill areas of training included in the basic phase of UPT; four were trained using simulator platform motion and four without. Following this, the students completed training in T-37 aircraft. The average performance of this group was compared with the average performance of a sample of eight students trained using the regular UPT syllabus. Estimates of training transfer and training effectiveness ratios were computed. In addition, problems occurring during the conduct of the study were documented.

### Results

Training transfer estimates for all major training areas were as follows: Advanced Contact, 4%; Formation, 13%; Navigation, 13%; Instruments, 38%; Basic and Presolo, 45%; with an overall average of 23%. Training effectiveness ratios were computed for the same areas of training and were as follows, respectively: 0.11, 1.00, 0.24, 0.52, 0.60, and 0.48 overall. No differences in performance were observed between subjects trained using platform motion and those trained without the use motion. A comparison of average aircraft check ride scores for instruments and contact flight revealed that the experimental group performed significantly better on the contact check ride. A summary of student and instructor opinions revealed a number of advantages and problems in the use of the simulator. A finding of particular significance was that if a full mission simulator is to be incorporated into a training program, the syllabus must be planned to provide maximum flexibility in both aircraft and academic scheduling.

### Conclusions

A sophisticated T-37 flight simulator provides a potential for effectively reducing flying requirements for major training areas in the T-37 UPT syllabus. While the sample sizes were too small for high confidence conclusions, there was no evidence in this study that platform motion in the simulator provided an increase in transfer of training. If a full mission simulator is to be successfully applied to a total training program, scheduling flexibility for both equipment and ground school will be an essential requirement.

## PREFACE

This study was conducted in support of project 1123, Flying Training Development, Dr. William V. Hagin, Project Scientist; task 112303, The Exploitation of Simulation in Flying Training, Mr. James F. Smith, Task Scientist; and work unit 11230321, ASUPT Operational Utilization Test, Mr. Robert R. Woodruff, Principal Investigator, assisted by Captain Stephen K. Rust.

This study was conducted by the Flying Training Division of the Air Force Human Resources Laboratory (AFSC) and supported by the 82d Flying Training Wing (ATC) and 82d Flying Training Wing/Deputy for Operational Research commanded by Lt Col Gerald L. Floyd.

Special appreciation is expressed to Lt Col Floyd and his staff who conducted the student training phase of this study. These people were: Captains Lewis V. Lake and John W. Stephens and Lieutenants James H. Gormley, Lucian A. Dade, III, Thomas I. Beil, Robert N. Cleveland, and Lee A. Lesher. In addition, superior HQ ATC support was provided through the efforts of Captain James D. Beggerly, ATC/DOY.

## TABLE OF CONTENTS



## LIST OF "\BLES

# FULL MISSION SIMULATION IN UNDERGRADUATE PILOT TRAINING: AN EXPLORATORY STUDY

## I. INTRODUCTION

The concept of procuring an Advanced Simulator for Undergraduate Pilot Training (ASUPT) was initiated in 1967 as a task area within a Director of Defense Research and Engineering program entitled Innovations in Training and Education (INNOVATE). The objective of the ASUPT task area was to design, develop, and utilize a state-of-the-art advanced simulation system for investigating the role of simulation in pilot training.

In December 1974, the ASUPT was accepted as installed at Williams AFB, AZ. At the time of its acceptance, it represented the most sophisticated full mission simulator in existence. It consisted of two high-fidelity T-37 cockpits mounted on individual synergistic six degree-of-freedom motion systems surrounded by a visual system which displayed computer-image-generated scenes. A complete array of advanced instructional feature capabilities was available, although not all of these features were fully developed for immediate operational research application. (For a more detailed description of ASUPT, see AFHRL-TR-74-43, pages 17–26.) The next several months were spent developing software to implement the advanced training features and to debug the ASUPT when used as a training device.

Obviously, planning for the most efficient research utilization of a device possessing all the capabilities of ASUPT was complex; there were many simulation research issues for which data were urgently needed. For example, earlier studies conducted by Air Force Human Resources Laboratory, Flying Training Division (AFHRL/FT) using a T-4G simulator (equipped with a two degree-of-freedom motion system and a one window field of view visual system) indicated that 48% of the instrument training hours and 10% of the basic contact hours used in the T-37 phase of UPT could be completed in a simulator (Woodruff & Smith, 1974). A follow-on question was "How much additonal time could be saved using the ASUPT configured to resemble the UPT Instrument Flight Simulator (IFS)?" Other issues involved the effects of motion on training, the field of view required for various categories of maneuvers, interactions of motion and visual systems, etc.; however, the uniqueness of the ASUPT which set it apart from any other device in existence was its total UPT mission capability. Therefore, one of the earlier studies planned was investigation of the use of the ASUPT in all phases of UPT T-37 training.

This report provides a description of the first effort in using a full mission simulator in a total training role. The objectives of the effort were: (a) to identify syllabus development and scheduling problems, (b) to identify features of the ASUPT which need improvement to permit effective training, (c) to provide an opportunity for research personnel to employ all ASUPT capabilities and features in the training role, (d) to provide an early test of the instrument training syllabus being developed for the IFS, (e) to provide a first (but by no means final) baseline estimate of what training effectiveness could be achieved by a full mission simulator in UPT, and (f) to obtain initial information on the effects of simulator motion on simulator training effectiveness.

## II. METHOD

### Test Plan

As in the development of any test plan, consideration was given to many conventional study design characteristics; however, in this study, two of those considered were of such significance as to require explanation. First, the ASUPT possessed some capability for use in *all* phases of UPT of which most, unlike instrument training, had never been addressed in any training program involving simulator scheduling. Therefore, it was anticipated that despite prestudy planning efforts, a number of unforseen student/syllabus flow problems would be encountered. Second, while a basic experimental paradigm which included three groups of subjects would have been desirable (the first trained using a special syllabus and the ASUPT, the second trained using only the special syllabus, and a third trained using the conventional syllabus), such a design was impractical until more was known relative to the number, type, and significance of problems which would be encountered while using the ASUPT in a total mission training role. As a result of these and other considerations, the study was planned to be exploratory, and the requirement for a control group trained using the new syllabus without the ASUPT deleted. However, since Air Training Command (ATC) was implementing a new T-37 phase syllabus with the same class planned for this study, training data on a sample of these students would be collected for comparative data.[1]

Eight students (the experimental group) were trained in all flying skills included in the basic phase of UPT using the ASUPT. Half of these students received training with the ASUPT motion system operational and half with the motion system off. After simulator practice, all students proceeded to T-37 aircraft and completed all basic pilot training requirements to phase standards as specified in the ATC July 1975 syllabus (ATC, 1975). Students were given the required ATC check rides, administered by the 96th Flying Training Squadron Check Section, as soon as judged ready by their instructor pilots (IP). Academic training was completed on the same schedule as the remainder of their assigned class.

Eight additional students were selected as a control group, and their progress through the regular UPT program was monitored. No special treatment was specified.

Data collected for both groups included the number of simulator and aircraft hours used in each phase of training and check scores achieved on T-37 aircraft check rides. In addition, their performance was followed through the T-38 phase of UPT to obtain some information concerning longer range effects of the special treatment.

Two minor conditions of the motion/no-motion portion of this test need to be mentioned because of their possible influence on the results. First, the ASUPT G-seat was not used in order to make conditions comparable to a previous motion/no-motion investigation at this laboratory. Second, one exception was made to the treatment of the no-motion group. Since aircraft buffet is a primary cue of impending stall in the T-37 and, in the opinion of the IPs, simulator training without these cues would be ineffective, the use of motion when teaching stalls was permitted for all students.

**Syllabus**

The special syllabus of instruction developed for training the experimental students closely paralleled the ATC July 1975 syllabus. It was arranged in blocks of training; each block contained a group of tasks considered to be prerequisite to learning the tasks in the succeeding block. Simulator and aircraft training were interspersed to minimize delays between training in the simulator and demonstrating performance in the aircraft. Students were progressed on a proficiency basis; however, to meet scheduling constraints, minimum and maximum numbers of sorties were specified for each block. Performance standards required for advancement were clearly defined. Check rides were given in the ASUPT before going to the T-37 for the first time and after ASUPT instrument training to ensure that each student met the specified level of performance in the simulator before using aircraft hours; extra ASUPT training was given to students who failed to meet the specified standards. A thorough description of the syllabus development, structure, and use is contained in Weyer and Fuller, 1976.

**Subjects**

*Experimental Group*. Eight students were selected randomly from incoming UPT class 76–09 at Williams Air Force Base, Arizona. Selection was limited to USAF students whose records indicated they had less than 50 hours prior flying training and who were not Air Force navigators.[2]

[1]To maintain clarity for the remainder of the report, the standard terms "experimental" and "control" groups will be used with the full understanding that, in the strict experimental sense, the groups involved do not meet accepted criteria for such designations.

[2]It was discovered later that one of the selected students did have about 200 hours prior light airplane experience, which was not shown in the records when selection was made. This student turned out to be better than average, but not exceptional in the subject group.

Two students from the original sample were lost shortly after training in ASUPT began; one because of withdrawal of a medical waiver and the other due to failures on several academic tests and unsatisfactory progress in the simulator.[3]

A third student included in the original sample experienced difficulty in his early ASUPT training and required the maximum time programmed. When later scheduling problems resulted in further delay, he was moved back to class 76–10. Thus, five students from class 76–09 and three from 76–10 were in the subject group which completed the experimental program.

*Control Group.* Using the same criteria as used with the experimental group, eight additional students were selected from the regular training program to serve as a control group. It was the goal of the regular training program to maintain an average of 90 flying training hours, but some variation was permitted, making the use of a comparison sample appropriate. Five students were chosen from class 76–09 and three from 76–10 to provide a control group; this composition paralleled that of the experimental group.

**Instructor Pilots**

Seven IPs from the 82d Flying Training Wing, Williams AFB, AZ, participated in this test program. Each IP was assigned a single student, except for one, who was assigned two. IP-student relationships were the same as in the normal training program. The IPs were given instruction and experience in the operation of the ASUPT instructor consoles and in flying ASUPT from the right seat in the cockpit. Since no prior comparisons of the relative effectiveness of using either IP position had been made, the IPs were instructed on the operation of each station and were permitted to use the position they felt would allow them to instruct most effectively.

**Proficiency Advancement**

Students progressed in both the simulator and the aircraft according to their demonstrated proficiency. Proficiency advancement in the simulator was used in recognition of individual differences in learning rate and to promote efficient use of ASUPT. In the aircraft, however, its primary purpose was to permit assessment of benefit derived from simulator training by noting differences in flying hours required by experimental and control group students.

**IP Opinion Questionnaires/Interviews**

A questionnaire about ASUPT capabilities was administered to the IPs after they had observed student performance in the aircraft (i.e., after basic contact and presolo student training in ASUPT.)

At the end of the program, the IPs were also interviewed extensively concerning human engineering design of the ASUPT operator and instructor positions. Due to the volume of this material, it is not included in this report; it will be published in a separate document.

## III. RESULTS AND DISCUSSION

Earlier studies conducted by AFHRL/FT indicated that a more definitive means of measuring training effectiveness is the use of trials to criterion (as opposed to training hours). The use of such a measure permits omission of nonrelevant overhead flying time (i.e., proceeding to and from a practice area); however, due to the exploratory nature of this study, it was decided that the conventional measure of hours would be used thereby reducing IP training time required for both experimental and control group IPs and investigator monitoring time required over the extended period of the study. Therefore, discussions concerning training effectiveness results obtained in this study will be in terms of simulator or aircraft hours.

---

[3] In accordance with a prior agreement with ATC, he was removed from the test program and returned to regular training with his class; he was later eliminated from pilot training.

**Simulator Hours**

Table 1 provides a summary of ASUPT and T-4 trainer hours used by the experimental and control groups, respectively. These hours are shown by category of training and reflect time spent in learning flying skill objectives. Additional simulator hours (5.6) were used by each student in learning normal and emergency procedures training; however, since these were enabling objectives, and the same for all students, they were omitted from the totals in Table 1.

*Table 1.* **Simulator Flying Hours Used by Experimental and Control Group Students by Segments of UPT, Totals and Averages**

| Column | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|
| Students | | Training Segment | | | | | | |
| Class | Ident | Basic and Presolo | Advanced Contact | Night Flying | Instru-ments | Forma-tion | Naviga-tion | Total |
| 76–09 | Exp A | 19.0 | 6.3 | 1.3 | 22.0 | 2.0 | 7.7 | 58.3 |
| 76–09 | Exp B | 20.3 | 5.4 | 1.3 | 31.1 | 0 | 7.8 | 65.9 |
| 76–09 | Exp C | 16.1 | 7.8 | 0 | 18.5 | 2.0 | 8.2 | 52.6 |
| 76–09 | Exp D | 19.1 | 6.7 | 0 | 23.0 | 2.0 | 7.5 | 58.3 |
| 76–09 | Exp E | 19.2 | 7.6 | 1.3 | 22.8 | 1.6 | 7.8 | 60.3 |
| 76–10 | Exp F | 19.3 | 5.6 | 1.0 | 22.2 | 0 | 7.8 | 55.9 |
| 76–10 | Exp G | 17.5 | 4.9 | 1.3 | 22.9 | 0 | 7.8 | 54.4 |
| 76–10 | Exp H | 23.7 | 5.5 | 1.3 | 30.2 | 2.0 | 7.5 | 70.2 |
| Average | | 19.3 | 6.2 | 1.3[a] | 24.1 | 1.9[a] | 7.8 | 59.5[c] |
| 76–09 | Cnt I | | | | 14.4[b] | | 3.2 | 17.6 |
| 76–09 | Cnt J | | | | 13.6 | | 3.2 | 16.8 |
| 76–09 | Cnt K | | | | 13.6 | | 3.2 | 16.8 |
| 76–09 | Cnt L | | | | 13.6 | | 3.2 | 16.8 |
| 76–09 | Cnt M | | | | 14.4 | | 3.2 | 17.6 |
| 76–10 | Cnt N | | | | 13.6 | | 3.2 | 16.8 |
| 76–10 | Cnt O | | | | 13.6 | | 3.2 | 16.8 |
| 76–10 | Cnt P | | | | 13.6 | | 3.2 | 16.8 |
| Average | | | | | 13.8 | | 3.2 | 17.0 |

[a]Averages based on only those students who flew simulator missions.

[b]The simulator used by the control group was the T-4.

[c]Average total includes students who did not train in formation and night flying.

The four columns in Table 1 which have no entries for the control group section (i.e., 1, 2, 3, and 5), reflect UPT simulator training objectives that can be addressed only if a visual system is available. Experience with the ASUPT indicated most training objectives in Basic and Presolo, and Advanced Contact could be practiced; however, practice on Night Flying and Formation was different. For Night Flying, only one aircraft ride is given, and it is basically for experience. It is not a check item; therefore, proficiency in the simulator was not specified, and the practice ride was given only if time permitted. (It was the general consensus of the IPs that the ASUPT night scene available at the time was inadequate for effective night transition training.)

With respect to formation training in ASUPT, no students had been trained using the formation scene prior to this study. After a few trials, it became apparent that ASUPT was extremely difficult for beginning students, and it was decided that little training would be achieved. As a result, this training area was deemphasized and, in some cases, omitted if any scheduling problems occurred. (The validity of this decision is discussed further in the Results section.)

**Aircraft Flying Hours**

Table 2 provides a summary of T-37 aircraft flying hours used by each student who participated in this study; average and total times for both the experimental and control groups are included. The first eleven vertical columns represent all segments of the flying training program; when summed across, the total is the number of T-37 aircraft hours used by each individual. Not all of the times shown in these columns were subject to reduction as a result of simulator training. For example, columns 2, 4, and 5 were ATC required sorties and were irreducible (one aircraft sortie ranged from 1.1 to 1.5 hours). Differences in column 3 occurred as a result of IP recommendations wherein it was believed that only one area solo ride was required, whether or not a simulator was used. Columns 7 and 9 reflect mandatory check rides which required at least one sortie each per student; hours in addition to one sortie in each of these columns indicate that, for some reason, some number of rechecks was necessary. The remainder of the columns (e.g., 1, 6, 8, 10, and 11) show aircraft hours used in areas of training where simulator effectiveness was relevant, and where the computation of hours saved and training effectiveness ratios (TER) as included at bottom of Table 2, were appropriate.

As noted earlier, to meet operational scheduling constraints, the study syllabus included an estimated maximum schedule of 75.3 hours per student as compared to the 90 hours required in the regular syllabus. This estimate was based on the judgement of instructor pilots and scientists who were experienced in the use of simulators in pilot training. Table 2 shows that two students exceeded 75.3 hours. These two experimental students used close to the maximum scheduled syllabus hours in early phases of training, and then both failed their instrument checks. The experimental syllabus provided that a student who failed a category check ride was "...authorized additional hours to increase his flying time in that category up to that specified in the ATC syllabus..." (Weyer & Fuller, 1976); additional flying time received under this provision pushed their totals beyond the 75.3 estimate.

*Figures, presented in the % Saved row*, were computed using the average hours for each group and indicate the percent of hours required in the regular syllabus which were not required by the experimental group. As noted earlier, these savings cannot necessarily be attributed to ASUPT; they could have resulted from the revised syllabus; however, since the study syllabus closely paralleled that used in the regular course, it is believed that most of the differences did result from use of the ASUPT.

While a reduction of 38% in instrument training time (Table 2, Column 8) over a new UPT syllabus (which had already reduced the required aircraft training hours from 20.8 to 14.4) was respectable, it was less than anticipated; particularly considering that ATC was interested in obtaining validation for the decision that only check rides would be required in the aircraft when the IFS became available (ATC, 1975, p. 45). The instrument training portion of the test syllabus was planned to partially validate this concept and instructors were encouraged to hold aircraft instrument training flights to two sorties, if possible. (A maximum of six aircraft sorties was programmed in the syllabus.) The IPs followed this guidance tempered by their own judgement. The result was that four of the eight test subjects failed their first instrument check; one of these failed his recheck. Reasons noted for the failures included: pentration using the wrong very high frequency omnirange (VOR) station, failure to lower flaps on a ground controlled approach (GCA), poor altitude control on a GCA, and faulty instrument crosscheck on a GCA.

Several factors were suggested as contributing to the problem. First, the actual aircraft instrument check used in the new syllabus was more difficult for all students; 24% of the regular class failed their first check ride. Second, IPs were permitted to instruct from whatever ASUPT station they desired; usually the external console. From the console, they could not adequately detect or correct basic weaknesses such as student visual crosscheck procedures which required direct observation of student practices. Third, the IPs spent considerable time at the console acting as GCA controllers. The GCA display and the repeater flight instruments were widely separated; as a result, effective instruction time may have been reduced. Fourth, students had received check rides in the simulator, and their average performance was not regarded as outstanding; however, there was no official pass-fail status to this check. Finally, by the time the aircraft instrument check was received, each student (and instructor) had spent at least 50 hours in the ASUPT. Since no official recognition was provided for these efforts (i.e., accredited flying time), and because simulator check ride success was not an official criterion for getting through the program, it is believed a lack of motivation existed. In summary, the conduct of this exploratory study identified several problem areas which should be resolved prior to the conduct of subsequent studies and before simulators such as the

*Table 2.* **Aircraft Flying Hours Used by Experimental and Control Group Students by Segments of UPT, Totals, Averages, Percent Saved, and TERs**

| Column | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Students | | Training Segment | | | | | | | | | | | |
| Class | Ident | Basic and Presolo | First Solo | Area Solo | Night Flying | Solo Stage | Advance Contact | Contact Check | Instru-ments | Instrument Check | Forma-tion | Naviga-tion | Total |
| 76–09 | Exp A | 15.8 | 0.4 | 1.2 | 1.1 | 1.2 | 18.2 | 1.5 | 12.4 | 2.7 | 12.4 | 7.2 | 74.1 |
| 76–09 | Exp B | 18.8 | 0.5 | 1.3 | 1.3 | 1.2 | 18.2 | 1.4 | 13.8 | 4.3 | 13.6 | 6.3 | 80.7 |
| 76–09 | Exp C | 9.9 | 0.6 | 1.1 | 1.0 | 1.1 | 18.4 | 1.3 | 4.2 | 1.4 | 13.7 | 7.2 | 59.9 |
| 76–09 | Exp D | 14.9 | 0.5 | 1.3 | 1.4 | 1.2 | 18.3 | 1.3 | 8.0 | 3.1 | 12.6 | 7.2 | 69.8 |
| 76–09 | Exp E | 11.0 | 0.4 | 1.2 | 1.4 | 1.3 | 18.6 | 1.4 | 2.7 | 1.5 | 12.8 | 7.2 | 59.5 |
| 76–10 | Exp F | 15.2 | 0.3 | 1.3 | 1.2 | 1.2 | 18.9 | 1.5 | 8.6 | 1.4 | 16.2 | 7.4 | 73.2 |
| 76–10 | Exp G | 9.6 | 0.5 | 1.3 | 1.2 | 1.2 | 20.2 | 1.5 | 8.5 | 1.5 | 15.9 | 6.7 | 68.1 |
| 76–10 | Exp H | 18.3 | 0.5 | 1.1 | 1.1 | 1.2 | 19.1 | 1.4 | 13.9 | 3.0 | 12.8 | 7.4 | 79.8 |
| Average | | 14.2 | 0.5 | 1.2 | 1.2 | 1.2 | 18.7 | 1.4 | 9.0 | 2.4 | 13.7 | 7.1 | 70.7 |
| 76–09 | Cnt I | 24.9 | 0.5 | 2.0 | 1.2 | 1.1 | 21.6 | 2.7 | 14.1 | 1.4 | 15.2 | 8.4 | 93.1 |
| 76–09 | Cnt J | 24.0 | 0.6 | 2.4 | 1.2 | 1.1 | 17.9 | 1.4 | 14.6 | 1.4 | 15.4 | 7.7 | 87.7 |
| 76–09 | Cnt K | 23.2 | 0.5 | 2.7 | 1.2 | 1.1 | 19.8 | 3.3 | 13.4 | 1.3 | 12.8 | 9.2 | 88.5 |
| 76–09 | Cnt L | 25.7 | 0.5 | 2.6 | 1.2 | 0.9 | 21.9 | 2.8 | 15.4 | 3.0 | 13.3 | 8.2 | 95.5 |
| 76–09 | Cnt M | 25.9 | 0.6 | 2.2 | 1.1 | 1.1 | 18.8 | 1.3 | 13.9 | 1.5 | 15.3 | 8.7 | 90.4 |
| 76–10 | Cnt N | 26.9 | 0.4 | 2.4 | 1.1 | 1.1 | 20.7 | 2.8 | 15.9 | 1.6 | 14.7 | 7.1 | 94.7 |
| 76–10 | Cnt O | 25.0 | 0.5 | 2.3 | 1.1 | 1.2 | 16.9 | 1.4 | 13.8 | 1.5 | 15.3 | 8.7 | 87.7 |
| 76–10 | Cnt P | 29.8 | 0.5 | 2.1 | 1.1 | 0.6 | 17.6 | 1.6 | 14.1 | 1.6 | 16.1 | 7.6 | 92.7 |
| Average | | 25.7 | 0.5 | 2.3 | 1.2 | 1.0 | 19.4 | 2.2 | 14.4 | 1.7 | 14.8 | 8.2 | 91.3 |
| % Saved | | 45 | | | | | 04 | | 38 | | 13[a] | 13 | 23 |
| TER[b] | | 0.60 | | | | | 0.11 | | 0.52 | | 1.00[a] | 0.24 | 0.48 |

[a]Computed using performances of only the five experimental subjects who received ASUPT practice versus the total control group (see Table 1).

[b]Computation defined in text of report.

IFS can be expected to be used with maximum efficiency. Many of these can be corrected through syllabus revisions and increased control of the learning situation. In fact, since the study was exploratory, some treatment changes were instituted with the two students from class 76–10 (Table 2, F and G) and proved successful. These included: IP located in the cockpit, extra people to serve as GCA controllers, and de-emphasis on saving hours. These subjects passed simulator checks with better ratings, and each passed his first aircraft check ride.

Student performance in other areas of ASUPT training (all contact flying) shows various results. For example, results achieved in Basic and Presolo (Column 1) were about as anticipated and support the philosophy that simulators can be used very effectively in early stages of flying skill development.

The results obtained in Advanced Contact (Column 6) were disappointing; however, this showing is partially a reflection of the instrument check failure discussed earlier. Most of the Advanced Contact work occurred after the instrument check rides and, since the check ride failures resulted in an unanticipated requirement for additional aircraft sorties (for review and recheck), it was necessary to use aircraft scheduled for contact training to satisfy the instrument training requirements. Normal ATC operations required aircraft to be scheduled two weeks in advance; therefore, student contact training had to be delayed necessitating additional refresher flights. Subjectively, the IPs believed that the ASUPT was effective for Advanced Contact training, even though for the reasons stated above, the data reflect less dramatic confirmation.

The Formation training results (Column 10) require comment. Prior to this study, the ASUPT formation mode had been used only by experienced pilots, and most had noted difficulty in judging closure rates and in holding a steady fingertip formation position. During the training of students in this mode, additional problems were evidenced. When the computer image generation system became overloaded, it selectively dropped out parts of the lead aircraft. This was most disconcerting to the student who was trying to hold position and to learn to use key reference points which frequently disappeared. Similarly, discontinuities occurred when the lead aircraft passed from one window to the next as it did frequently during the early training periods. As a result of these problems, both IPs and students lost confidence in what training could be accomplished, and it was agreed that instead of training to criterion performance, each student would be given only two rides in the ASUPT. Further, since the priority was low, if scheduling problems occurred, formation sorties were the first to be cancelled. By reference to Table 1, it may be seen that three students received no formation training in ASUPT. Thus, the 13% figure shown in Table 2, Column 10 was derived based on only five experimental subjects.

While hours saved is interesting, a more significant measure of simulator usefulness with respect to cost savings is the training effectiveness ratio (TER). Such a ratio (Roscoe, 1971) provides an estimate of transfer efficiency as indicated by the ratio of practice hours saved to practice hours spent in a prior device; the higher the positive number, the greater the transfer efficiency. For this study, the computation was as follows:

$$\frac{\text{Aircraft Hours, Control Group} - \text{Aircraft Hours, Experimental Group}}{\text{Simulator Hours, Experimental Group} - \text{Simulator Hours, Control Group}} = \text{TER}$$

TERs for all relevant areas of training are provided at the bottom of Table 2 and, in most cases, the TERs tend to track % Saved estimates.[4] However, the more interesting figure is the ratio of 1.00 obtained for Formation. This ratio indicates that on the average, each hour spent in the ASUPT on this training task resulted in a one hour savings in the aircraft. Thus, it appears that the decision to de-emphasize formation training in the ASUPT may have been incorrect even though all persons concerned were in agreement, and their rationale possessed face validity.

[4]The denominators for instrument and navigation TERs were derived by subtracting simulator instrument training accomplished by the control group (Table 1) from that of the experimental group based on the assumption that for that level of task training, the devices were approximately equivalent.

### Check Ride Scores

Average instrument and contact check ride scores achieved by both experimental and control groups were compared to obtain some estimate of the quality of graduated students (scores of passing check rides were used). For instruments, the experimental group averaged 89.73% and the control group 89.82%; not significantly different.

On contact check rides, the experimental group received an average score of 90.85%; the average score achieved by conventionally trained students was 87.35%. This difference is statistically significant ($p < .01$) and indicates the experimentally trained students were better prepared for the contact check than were the regular students.

As noted earlier, the performances of both groups of students were followed into the T-38 phase of UPT. In the T-38 phase, the experimental students of class 76–09 received an average grade of 91.77% while the regularly trained 76–09 students received an average of 86.88%; also statistically significant ($p < .01$). These data suggest that whatever additional contact flying skills were learned using the ASUPT in the T-37 phase were retained throughout UPT.

### Motion/No-Motion

Table 3 shows the ratio by training category (except solo, check rides, and night flying) of simulator and flying hours used by the four students who trained in ASUPT with the motion turned on compared with the hours used by the four students who trained in the ASUPT with the motion system turned off. The ratios were obtained by dividing the hours used by the motion group by the hours used by the no-motion group. Remembering that all subjects were progressed on a proficiency basis, the ratios show that both groups required very nearly equal hours of training in the simulator; i.e., no practical or significant differences in average simulator training time requirements were identified that could be attributed to the motion condition. The ratios further show no practical or significant differences in average aircraft training time requirements.

*Table 3.* **Ratios of Average Hours Required to Complete Training by Motion and No-Motion Groups by Training Segment and Device**

| | Ratios[a] | |
|---|---|---|
| Training Segment | Simulator | Aircraft |
| Basic and Presolo | 0.93 | 1.02 |
| Advanced Contact | 1.11 | 0.95 |
| Instruments | 0.96 | 1.02 |
| Navigation | 1.01 | 0.97 |
| Total | 0.98 | 1.01 |

[a]Ratio computed by dividing the average number of training hours required by students trained using simulator motion by the comparable hours used by students trained without simulator motion.

The result of ASUPT training with and without motion suggests that there is little significant difference in training value between these conditions anywhere in the T-37 syllabus. No-motion students were given training in stalls with motion and, had they not been, the flying hours they saved in basic contact might have been less; however, there was no confounding in any other of the syllabus categories, and yet the motion/no-motion ratios for all categories including basic contact were nearly the same, and very close to 1.00.

**IP Judgements as to ASUPT Capabilities**

A questionnaire was administered to the IPs (instructing in the ASUPT) after they had the opportunity to observe the performance of the ASUPT-trained students during one or more T-37 aircraft sorties. The objective of this questionnaire was to obtain IP attitudes toward the ASUPT and their opinions of ASUPT capabilities.

Generally, the IPs liked the ASUPT; they rated it much better than the T-4 as an instructional device, and from an instructional environment viewpoint, slightly better than the aircraft. They liked the flexibility allowed by some of the advanced instructional provisions, and the ability to select weather and visibility conditions. Various negative factors were identified; but the principal one was simply that IPs like to fly aircraft.

More specifically, the IPs judged the ASUPT excellent for training procedures of all sorts because its flexible reset capability allowed convenient and rapid repetition of training events. Another strong feature of ASUPT was that its visual display enabled effective teaching of composite references.

The questionnaire also revealed a number of judged shortcomings in ASUPT:[5]

1. *The visual environment was inadequate for the students to learn area orientation, although they could learn to locate specific visual references.*

2. *Radio transmissions were unrealistic because of the lack of background chatter.* Students did not have to learn to sort their call signs out of the noise.

3. *The absence of other traffic in the visual environment was unrealistic and reduced the capability to teach clearing techniques.*

4. *During the final turn, movement of the runway image from one cathode ray tube (CRT) to another was not smooth; it jumped somewhat, thereby necessitating unexpected control adjustments which are not characteristic of real-life requirements.*

5. *There was insufficient ground detail in the visual environment during the final approach and flare for landing to allow students to adequately judge ground proximity.* The IPs recommended that ground textural cues be added in a rectangle extending three-quarters of a mile back from the runway threshold and extending 500 feet on both sides of the centerline. (Both two- and three-dimensional cues should be investigated.) They also recommended that cues such as tire marks be added to the runway.

## IV. FINDINGS

This study was exploratory in nature in which six objectives were addressed using a full mission simulator in the T-37 phase of UPT. Following is a summary of findings relative to each objective:

*Objective 1 – Identification of syllabus development and scheduling problems.* First, the conduct of the flying phase of this study in which students were progressed on a proficiency basis was hampered by inflexible academic prerequisites. As a result, some extra aircraft time was required for refresher training. Second, failures on instrument check rides and subsequent short-notice requirements for additional aircraft sorties proved incompatible with existing UPT aircraft scheduling techniques which required aircraft sorties to be scheduled two weeks in advance. Third, batched simulator time for areas of training in which students were progressed on a proficiency basis conflicted with the long lead time required to obtain aircraft sorties for flight skill validation. While differences in student learning rates caused most of these problems, differences were compounded by ASUPT unreliability. Although an 89% reliability figure for the study was recorded, occasional ASUPT component failures and less frequent total system failures caused increased simulator requirements which added to the scheduling problem. The usual array of routine problems (i.e., weather, aircraft aborts, academic failures, illness) which occur in any pilot training program was experienced, but those discussed above were unique to use of a full mission simulator and impacted the

[5]It should be noted that many of these items have been supported by other studies conducted later, and that where possible, ASUPT development efforts to correct the problems are in process.

results; in all cases, simulator effectiveness estimates were lowered. These data highlight a characteristic of any study involving the use of full mission training devices in an operational training program; if innovative training strategies are to be used which permit most efficient use of a full mission simulator, flexibility must be incorporated into the total program, including academic training and aircraft scheduling.

*Objective 2 – Identification of ASUPT characteristics which need further development.* Potential areas for improving ASUPT capabilities were: formation flying, night flying, landing approaches and flares, simplification of console operation, addition of random aircraft in the visual scene for training alertness, addition of more realistic random radio chatter, and, if possible, improved system reliability.

*Objective 3 – Provide experience in using total ASUPT capabilities.* Use of the ASUPT in student training indicated: students should wear personal equipment on missions just preceding aircraft sorties; short simulator periods are more efficient in early training and longer periods towards the end; student team sorties could be useful; use of the simulator increased training efficiency in learning to use composite reference; some portion of slow flight practice should be accomplished at pattern altitude; to keep motivation up over a total program, performance goals must be specified and go-no-go hurdles instituted; most simulator sorties should be conducted with the IP in the cockpit; and a console operator should be available to assist in GCA training.

*Objective 4 – Pretest of instrument syllabus for use with the IFS.* In addition to several relevant items listed above, student and IP comments indicated that to achieve closer relevance with the problems in aircraft flights, an instrument hood (like that used in the aircraft) should be used for simulator rides which occur just prior to aircraft instrument training sorties. In addition, it was indicated that if the goal of a check flight only in the aircraft is to be achieved, the aircraft instrument check should be delayed until later in the syllabus; i.e., after navigation training. The average simulator hours scheduled proved to be reasonably accurate. A final simulator check ride is necessary.[6]

*Objective 5 – Baseline Training Effectiveness Data.* Percentage estimates and training effectiveness ratios by area of training are provided in Table 2; however, it must be reiterated that these data were obtained in an exploratory study. If a follow-on study of this type is conducted which incorporates corrective measures for the problem areas noted, considerably better results can be expected.

*Objective 6 – The effects of motion on training effectiveness.* The sample size in this study was small; therefore, inferences concerning the value of simulator motion cannot be made with a high level of confidence. However, from the data obtained, there is no support that a synergistic six degree-of-freedom motion system as installed on the ASUPT increased training effectiveness in any area of the basic T-37 phase of UPT. IP users did indicate a requirement for some amount of heave or departure motion cueing when teaching stalls.

## V. CONCLUSION

This study has clearly shown that a sophisticated full mission flight simulator can be used to increase training effectiveness in the context of Air Force UPT. In spite of the difficulties encountered and the exploratory nature of the study, this test realized a reduction of one-quarter of the regularly scheduled flying training hours at a cost of only two simulator hours for each T-37 aircraft hour. The more spectacular demonstrations of training effectiveness occurred in instrument and basic contact training; the savings in instrument training has precedent, but the savings in basic contact training indicates an unexploited capability. A subjective assessment of the difficulties documented in this study indicates most can be significantly reduced, if not eliminated entirely. This assessment, combined with the positive opinions of ASUPT IPs, suggests that from a training effectiveness viewpoint, a full mission simulator could be developed which would achieve significant benefits in all major training areas in UPT; the degree to which such a system would be cost effective cannot be estimated from this study.

[6]Relevant findings listed under objectives 3 and 4 were incorporated and validated in a subsequent AFHRL/FT/ATC test of the proposed IFS syllabus.

## REFERENCES


Air Training Command. *Syllabus of training.* NO. P-V4A-A, July 1975.

Hagin, W.V., & Smith, J.F. *Advanced simulation in undergraduate pilot training (ASUPT) facility utilization plan.* AFHRL-TR-74-43, AD-786 411. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, June 1974.

Roscoe, S.M. Incremental transfer effectiveness (Revised). *Human Factors,* 1971, 13(3), 561–567.

Weyer, D.R., & Fuller, J.H. *Syllabus and student/instructor guide for use with a full mission simulator.* AFHRL-TR-76-90. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, December 1976.

Woodruff, R.R., & Smith, J.F. *T-4G simulator and T-4 ground training devices in USAF undergraduate pilot training.* AFHRL-TR-74-78, AD-A008 197. Williams AFB, AZ: Flying Training Division, Air Force Human Resources Laboratory, November 1974.



☆ U.S. GOVERNMENT PRINTING OFFICE: 1977—771-057/6